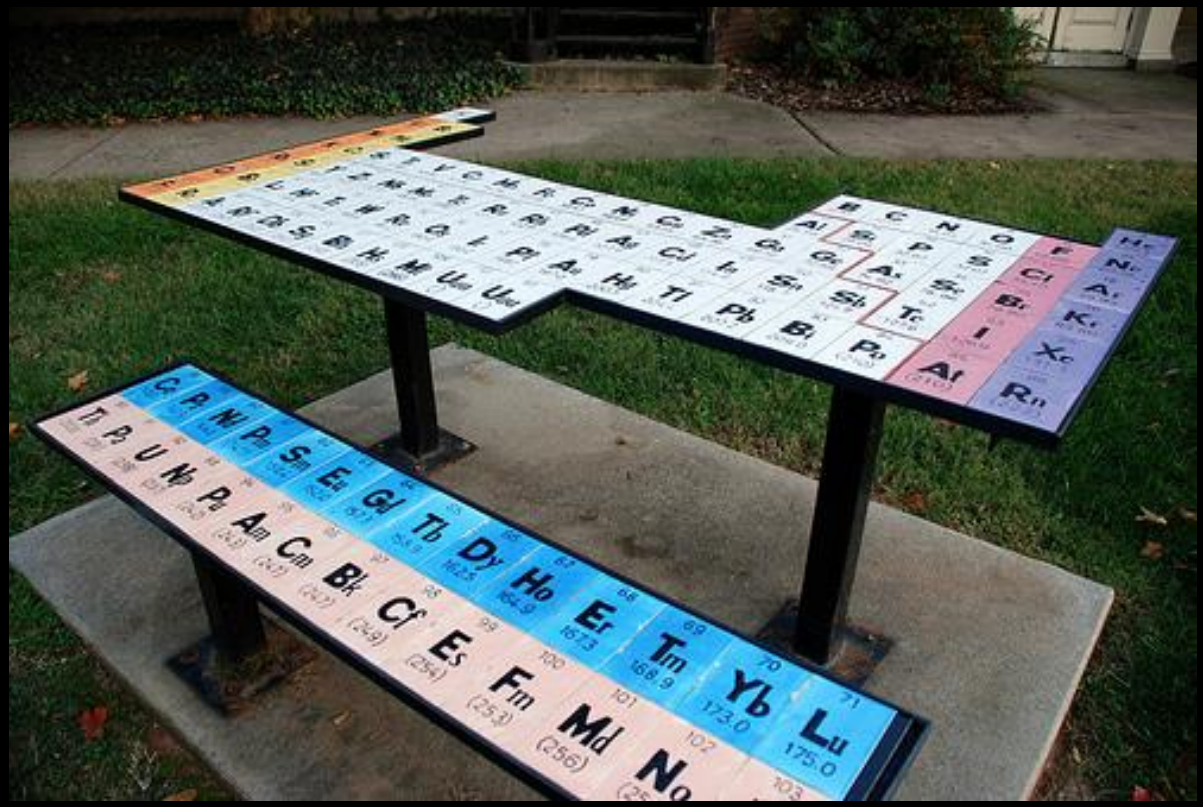
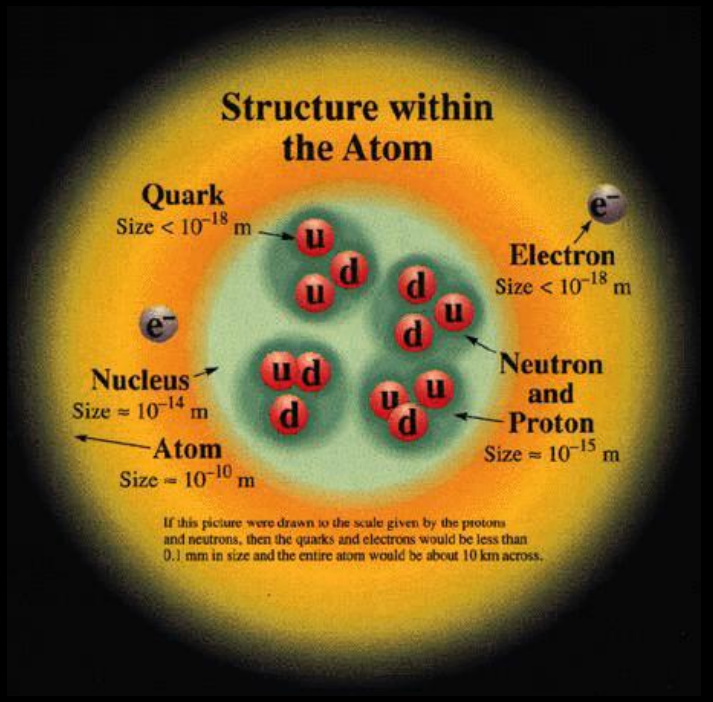
Learning
The Periodic Table of Elements



What are Atoms?

- *Atoms* are the simplest and smallest particle composed of *protons*, *electrons*, and *neutrons*.
- The number of protons in the nucleus of an atom is equal to its atomic number.
- Normally, the number of protons equals the number of electrons.


Structure within the Atom
Quark
Size < 10^{-18} m
Electron
Size < 10^{-18} m
Nucleus
Size ≈ 10^{-14} m
Neutron and Proton
Size ≈ 10^{-15} m
Atom
Size ≈ 10^{-10} m
If this picture were drawn to the scale given by the protons and neutrons, then the quarks and electrons would be less than 0.1 mm in size and the entire atom would be about 10 km across.

The Atom's Family

Protons, Neutrons and Electrons

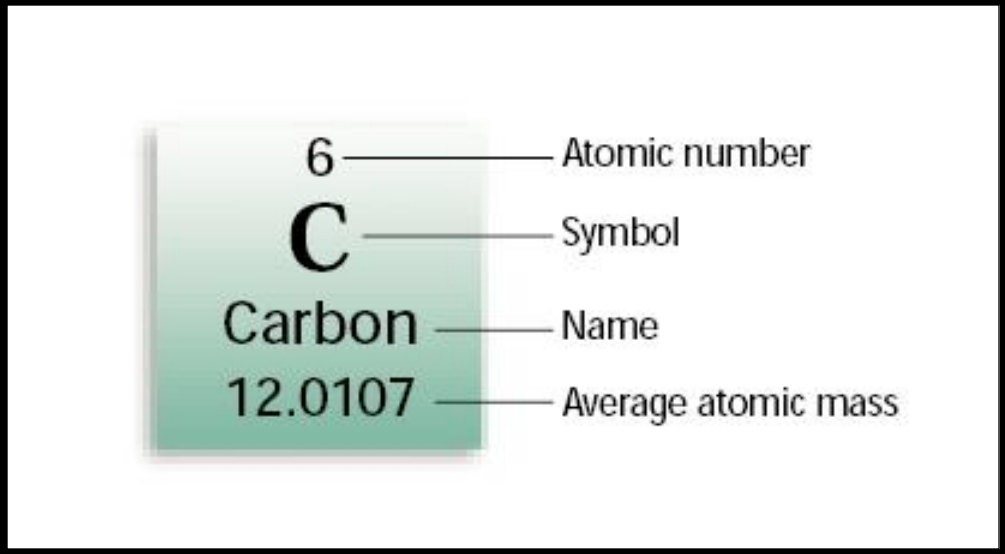
- A *proton* is a positively charged particle inside the nucleus.
- A *neutron* is a neutral particle also inside the nucleus.
- An *electron* is a negatively charged particle that orbits the nucleus.

What is the Periodic Table of Elements?

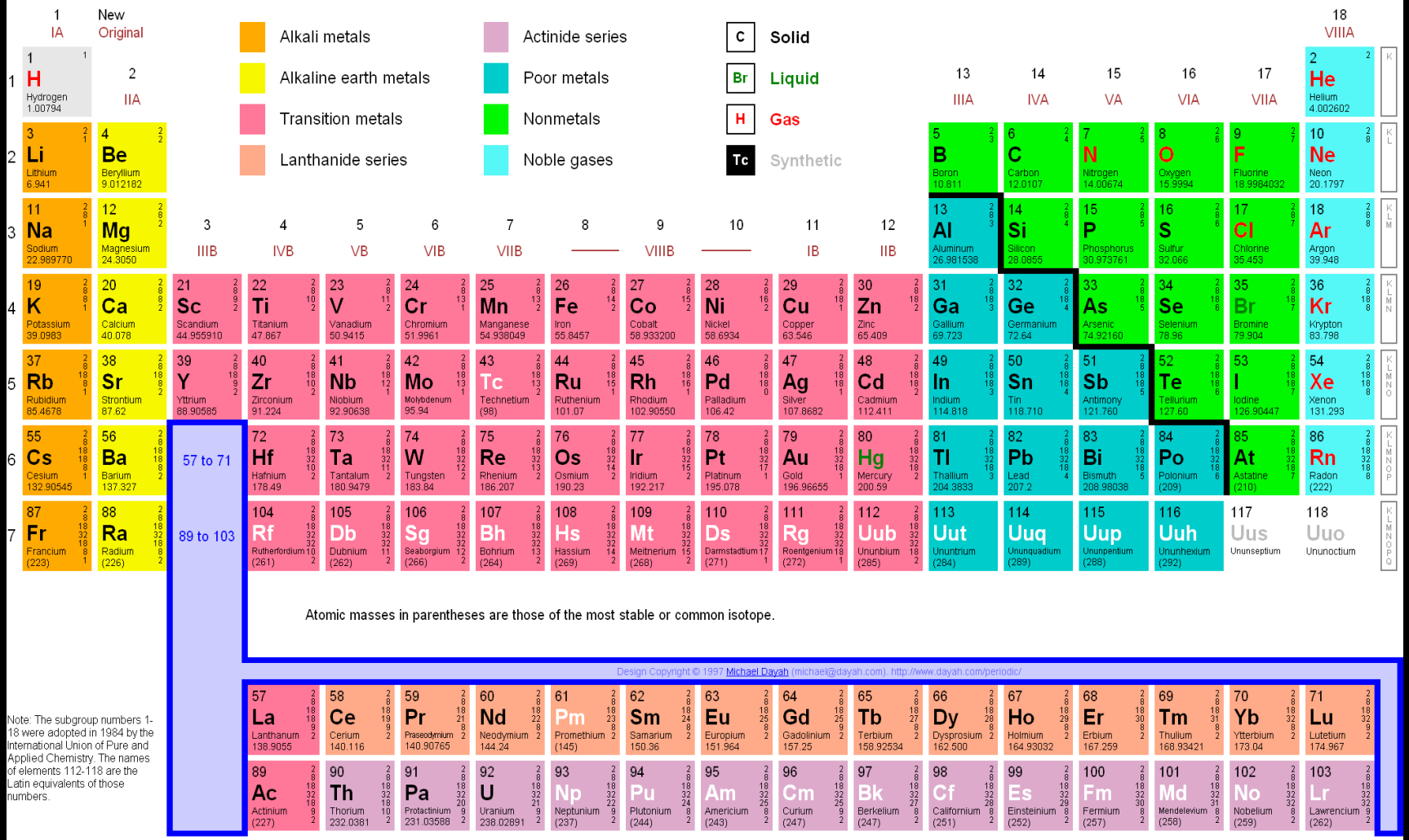
- *Elements* are substances that cannot be broken down any further by chemical means. There are over 100!
- *The Periodic Table* is the arrangement of these elements by increasing atomic number and similar properties.

Elements

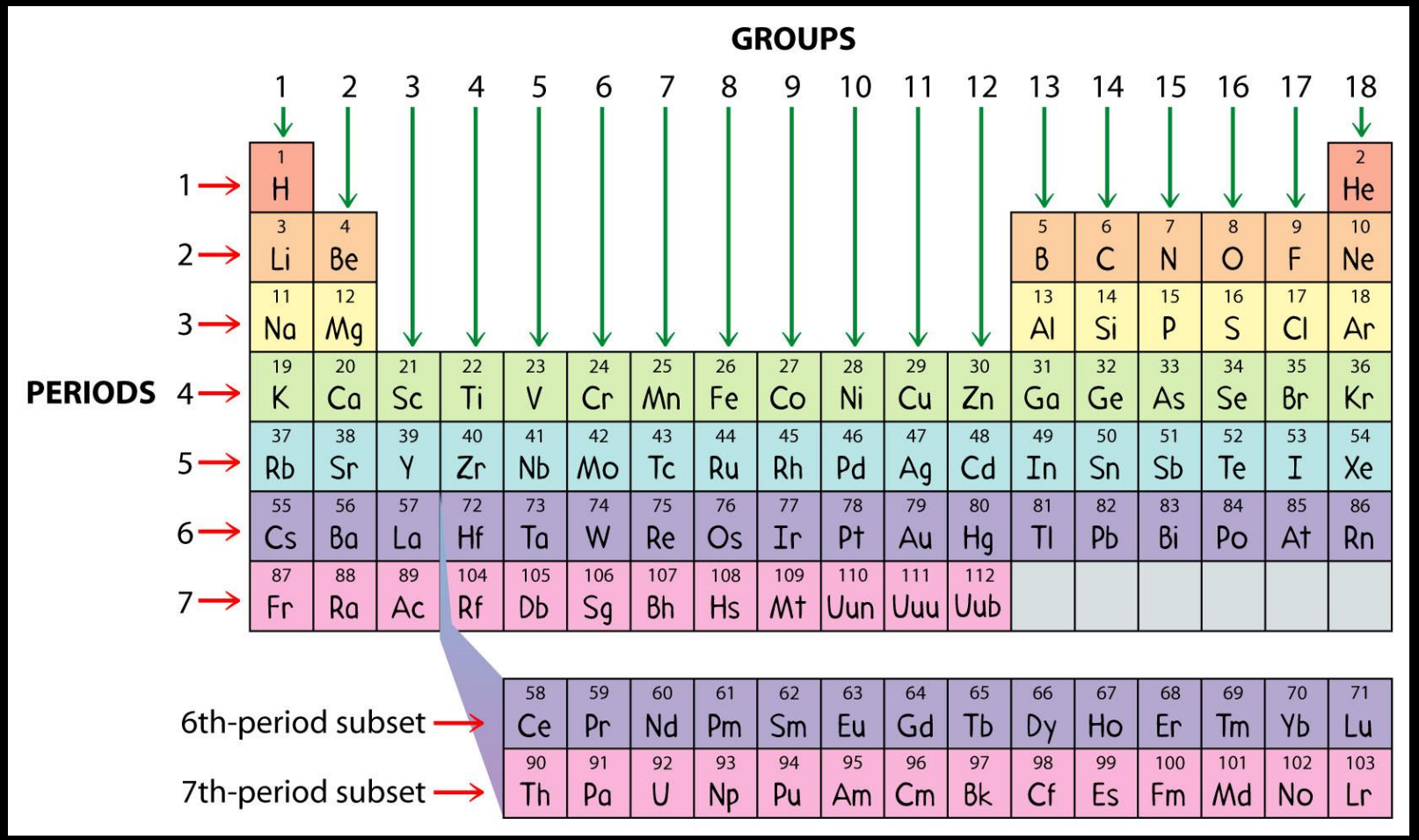
- Each element on the Periodic Table has an *atomic number*, *symbol*, *name* and *average atomic mass*.
- *Atomic number* – the number of protons found in the nucleus of an atom.
- *Average atomic mass* – the mass of an atom including the protons, neutrons and electrons.



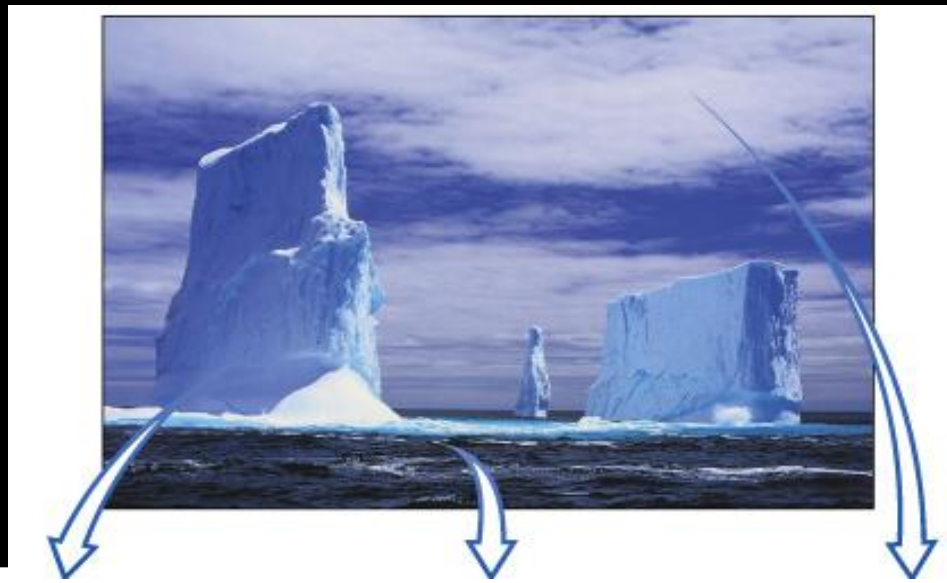
Periodic Table of the Elements



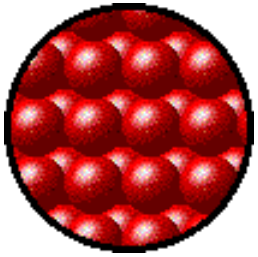
How is it Arranged?


GROUPS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
PERIODS
1 → H He
2 → Li Be B C N O F Ne
3 → Na Mg Al Si P S Cl Ar
4 → K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
5 → Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
6 → Cs Ba La Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
7 → Fr Ra Ac Rf Db Sg Bh Hs Mt Uun Uuu Uub
6th-period subset → Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
7th-period subset → Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr

The red lines show the different periods and the green lines show the groups.



The Three States of Matter

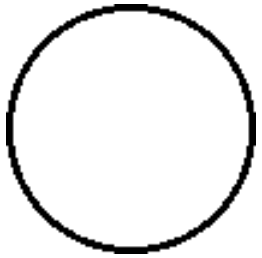


Solid

- Particles held tightly
- Very close together
- Regular arrangement
- Vibrate
- Can't move from place to place

Liquid

- Particles held weakly
- Very close together
- Random arrangement
- Vibrate
- Constantly move past each other



Gas

- No attraction between particles
- Far apart
- Random arrangement
- Vibrate
- Move quickly in all directions

Grouped Elements Have Similarities

- Elements in the same group have similar properties. Remember, groups are columns.
- *Chemical Property* - a property used to characterize materials in reactions that change their identity. Ex: burning something.
- *Physical Property* - a characteristic of a substance that can be observed without changing the substance into something else. Ex: measuring something's length, color, mass or volume.

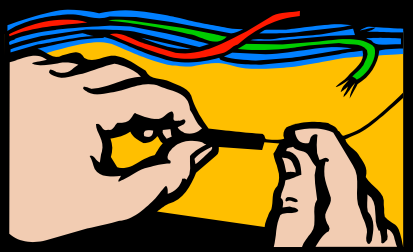
Metals, Nonmetals and Metalloids

- The major categories of elements are the metals, non-metals, and metalloids.
- *Metals* are lustrous, malleable, and are good conductors of heat and electricity.
- *Non-metals* are elements that do not share the properties of metals.
- *Metalloids* are elements that share some, but not all the properties of metals.

Metals - Lustrous, Malleable, and Good Conductors?

These are *physical properties* of metals

- *Lustrous* means shiny or reflective of light.
  - Coins and jewelry are shiny and reflective .
- *Malleable* means capable of being shaped.
  - Aluminum foil is shaped or molded around food items to keep them fresh.
- Being a *Good Conductor* means being able to allow electricity and heat to flow through.



  - When you think about the wires we use for electrical devices, they are mostly made of copper and other metals.

3	Li	Lithium 6.941	2 1
11	Na	Sodium 22.989770	2 8 1
19	K	Potassium 39.0983	2 8 8 1
37	Rb	Rubidium 85.4678	2 8 18 8 1
55	Cs	Cesium 132.90545	2 8 18 18 8 1
87	Fr	Francium (223)	2 8 18 32 18 8 1

Alkali Metals

- Elements in *Group 1* (not including Hydrogen).
- Very reactive metals. Always combine with something else in nature.
- Salt – an Alkali Metal, *Sodium*, and another element, *Chlorine*, combined.

4	Be	Beryllium 9.012182	2 2
12	Mg	Magnesium 24.3050	2 8 2
20	Ca	Calcium 40.078	2 8 8 2
38	Sr	Strontium 87.62	2 8 18 8 2
56	Ba	Barium 137.327	2 8 18 18 8 2
88	Ra	Radium (226)	2 8 18 32 18 8 2

Alkaline Earth Metals

- Elements in *Group 2*.
- Reactive Metals that are always combined with non-metals in nature.
- Several of these elements are important mineral nutrients, like Calcium.

Transition Metals

- Elements in *Groups 3-12*.
- Less reactive, harder metals.
- Includes metals used in jewelry, money and construction.

21 2 8 9 2 **Sc** Scandium 44.955910	22 2 8 10 2 **Ti** Titanium 47.867	23 2 8 11 2 **V** Vanadium 50.9415	24 2 8 13 1 **Cr** Chromium 51.9961	25 2 8 13 2 **Mn** Manganese 54.938049	26 2 8 14 2 **Fe** Iron 55.8457	27 2 8 15 2 **Co** Cobalt 58.933200	28 2 8 16 2 **Ni** Nickel 58.6934	29 2 8 18 1 **Cu** Copper 63.546	30 2 8 18 2 **Zn** Zinc 65.409
39 2 8 18 9 2 **Y** Yttrium 88.90585	40 2 8 18 10 2 **Zr** Zirconium 91.224	41 2 8 18 12 1 **Nb** Niobium 92.90638	42 2 8 18 13 1 **Mo** Molybdenum 95.94	43 2 8 18 13 2 **Tc** Technetium (98)	44 2 8 18 15 1 **Ru** Ruthenium 101.07	45 2 8 18 16 1 **Rh** Rhodium 102.90550	46 2 8 18 18 0 **Pd** Palladium 106.42	47 2 8 18 18 1 **Ag** Silver 107.8682	48 2 8 18 18 2 **Cd** Cadmium 112.411
72 2 8 18 32 10 2 **Hf** Hafnium 178.49	73 2 8 18 32 11 2 **Ta** Tantalum 180.9479	74 2 8 18 32 12 2 **W** Tungsten 183.84	75 2 8 18 32 13 2 **Re** Rhenium 186.207	76 2 8 18 32 14 2 **Os** Osmium 190.23	77 2 8 18 32 15 2 **Ir** Iridium 192.217	78 2 8 18 32 17 1 **Pt** Platinum 195.078	79 2 8 18 32 18 1 **Au** Gold 196.96655	80 2 8 18 32 18 2 **Hg** Mercury 200.59	
104 2 8 18 32 32 10 2 **Rf** Rutherfordium (261)	105 2 8 18 32 32 11 2 **Db** Dubnium (262)	106 2 8 18 32 32 12 2 **Sg** Seaborgium (266)	107 2 8 18 32 32 13 2 **Bh** Bohrium (264)	108 2 8 18 32 32 14 2 **Hs** Hassium (269)	109 2 8 18 32 32 15 2 **Mt** Meitnerium (268)	110 2 8 18 32 32 17 1 **Ds** Darmstadtium (271)	111 2 8 18 32 32 18 1 **Rg** Roentgenium (272)	112 2 8 18 32 32 18 2 **Uub** Ununbium (285)	

Boron Family

- Elements in *Group 13*.
- Boron has properties of both metals and non-metals.
- The rest of the elements in this group are metals.

5	13	31	49	81	113
2 3	2 8 3	2 8 18 3	2 8 18 18 3	2 8 18 32 18 3	
B	Al	Ga	In	Tl	Uut
Boron	Aluminum	Gallium	Indium	Thallium	Ununtrium
10.811	26.981538	69.723	114.818	204.3833	(284)

Carbon Family

- Elements in *Group 14*.
- Contains elements important to life and computers.
- Carbon is the basic element in all organic compounds.
- Silicon and Germanium are important semiconductors.

6	2 4
C	
Carbon	
12.0107	

14	2 8 4
Si	
Silicon	
28.0855	

32	2 8 18 4
Ge	
Germanium	
72.64	

50	2 8 18 18 4
Sn	
Tin	
118.710	

82	2 8 18 32 18 4
Pb	
Lead	
207.2	

114
Uuq
Ununquadium
(289)

7
N
Nitrogen
14.00674
2
5

15
P
Phosphorus
30.973761
2
8
5

33
As
Arsenic
74.92160
2
8
18
5

51
Sb
Antimony
121.760
2
8
18
18
5

83
Bi
Bismuth
208.98038
2
8
18
32
18
5

115
Uup
Ununpentium
(288)

Nitrogen Family

- Elements in *Group 15*.
- Nitrogen makes up more than ¾ of our atmosphere.
- The red tip of matches is made of phosphorous.

8 2 6
O
Oxygen
15.9994

16 2 8 6
S
Sulfur
32.066

34 2 8 18 6
Se
Selenium
78.96

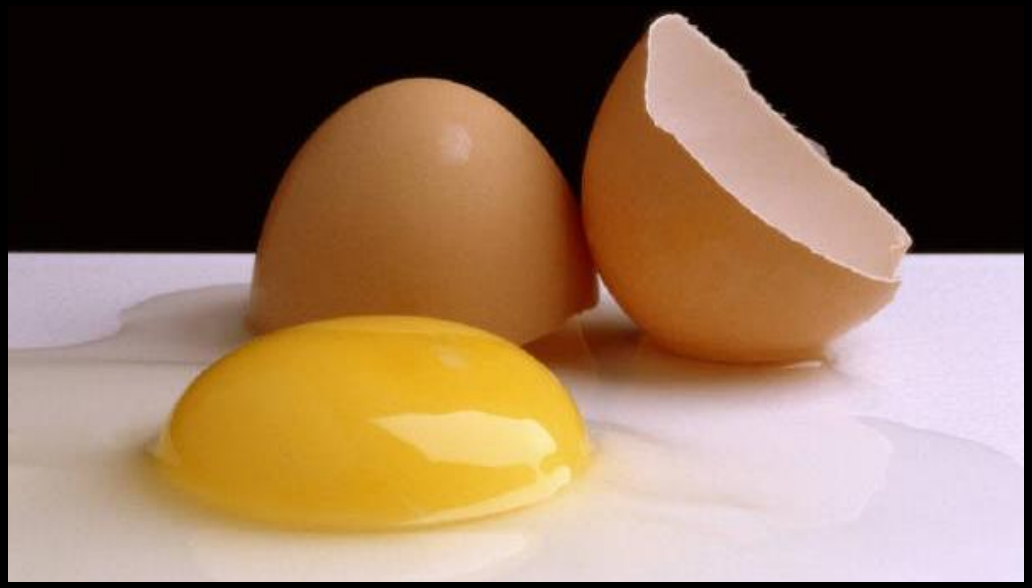
52 2 8 18 18 6
Te
Tellurium
127.60

84 2 8 18 32 18 6
Po
Polonium
(209)

116
Uuh
Ununhexium
(292)

Oxygen Family or Chalcogens

- Elements in *Group 16*.
- Oxygen is necessary for respiration.
- Many things that have a bad odor contain sulfur.



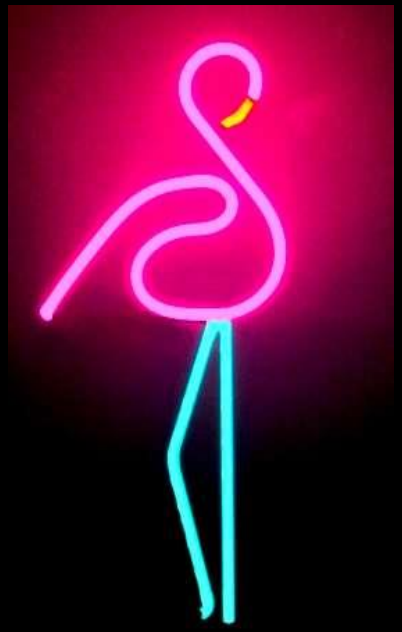
Halogens

9	2 7
F	
Fluorine	
18.9984032	
17	2 8 7
Cl	
Chlorine	
35.453	
35	2 8 18 7
Br	
Bromine	
79.904	
53	2 8 18 18 7
I	
Iodine	
126.90447	
85	2 8 18 32 18 7
At	
Astatine	
(210)	
117	
Uus	
Ununseptium	

- Elements in *Group 17*.
- Very reactive, diatomic non-metals.
- Always found combined with other elements in nature.
- Chlorine is used to keep bacteria out of swimming pools.

Noble Gases

- Elements in *Group 18*.
- VERY reactive gases.
- Used in lighted neon signs.
- Helium is used to make party balloons float.

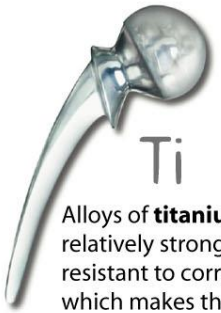


2	2	
He		
Helium		
4.002602		
10	2	
	8	
Ne		
Neon		
20.1797		
18	2	
	8	
	8	
Ar		
Argon		
39.948		
36	2	
	8	
	18	
Kr	8	
Krypton		
83.798		
54	2	
	8	
	18	
	18	
Xe	8	
Xenon		
131.293		
86	2	
	8	
	18	
	32	
Rn	18	
Radon	8	
(222)		

Elements Used Everyday

Ag

If this **silver** mug were filled with boiling water, the handle would quickly become too hot to handle because silver is one of the best conductors of heat.



Ti

Alloys of **titanium** are relatively strong and resistant to corrosion, which makes them useful for hip implants.

About 50,000 pounds of synthetic diamonds are produced from **carbon** each year.

C

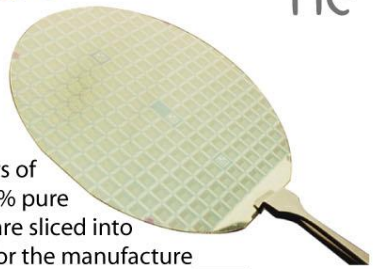
Helium is formed underground as a by-product of radioactive decay.

He

Zn

Zinc has a low melting point and is commonly used in making coins.

Si



Cylinders of 99.9999% pure **silicon** are sliced into wafers for the manufacture of integrated circuits.

Hg

Mercury freezes at −40°C and is a liquid at room temperature.

Br

Bromine is a dark orange liquid that readily vaporizes at room temperature.

1 H																	2 **He**
3 Li	4 Be											5 B	6 **C**	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 **Si**	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 **Ti**	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 **Zn**	31 Ga	32 Ge	33 As	34 Se	35 **Br**	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 **Ag**	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 **Hg**	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub						

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Metal Metalloid Nonmetal

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Can you think of any elements you use every day?